Enhancing Indoor Air Quality: Developing Air Quality Detectors for Assessing air quality of Sansevieria trifasciata (Snake Plant), Codiaeum variegatum (Garden Croton), and Epipremnum aureum (Golden Pothos)

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Abstract

The prevalence of air pollution in the Philippines contributes significantly to public health issues, including asthma, respiratory infections, and potentially fatal conditions such as cancer and stroke. Globally, air pollution is accountable for over 6.5 million deaths annually, highlighting its profound impact on human health and the environment. Common pollutants stem from various human activities and household items such as paints and cleaning supplies, necessitating a focus on improving indoor air quality to prevent further contamination of the surrounding environment. Technological advancements offer solutions through devices like air purifiers, but accessibility and affordability remain barriers, particularly in regions like the Philippines with economic constraints. Leveraging the country's rich biodiversity, notably its diverse array of plant species, presents a promising alternative. Indoor plants such as Sansevieria trifasciata (Snake Plant), Codiaeum variegatum (Garden Croton), and Epipremnum aureum (Golden Pothos) are readily available and offer natural air purification benefits.

The study proposes utilizing Arduino-based monitoring systems to assess air quality, providing real-time data on pollutant levels. By integrating these monitoring systems with the aforementioned plant species, the research aims to detect and reduce harmful gas concentrations in the atmosphere. This approach not only safeguards environmental health but also promotes a cleaner and healthier living environment for all inhabitants. Ultimately, the study endeavors to contribute to sustainable environmental practices and public wellness through innovative, accessible, and cost-effective solutions.

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INTRODUCTION

Air pollution is one of the primary reasons as to why Filipinos suffer from health issues such as asthma and respiratory infections, as well as one of the potential causes of severe health cases such as cancer, stroke, and lung cancer. According to the National Institute of Environment Health Sciences in 2023, air pollution is responsible for the cause of more than 6.5 million deaths each year globally. It does not only negatively contribute to the health of a person, but to their environment and the world around them. This shows that air quality can make drastic changes to the surroundings, which may lead to worse events in the future. These harmful gasses are not only caused by various human activities but can be present anywhere, especially in paints, cleaning supplies, smoke and others. Improving indoor air quality is essential since pollutants are almost certainly trapped therefore, it could pollute the surrounding area. Small actions can cause enormous effects to the world, which is why there must be innovative ways in order to prevent and lessen such events.

As technological advancements have changed the world through the years, it makes it easier to make devices such that there have already been present devices in detecting air quality such as air purifiers, filters,and etc. Although, inflation has been increasing through the years, especially in the Philippines. Not everyone has enough budget for their needs, let alone access or money to afford any of these products. This is why there has to be alternative solutions that are cheaper, accessible and more effective. According to the Convention of Biological Diversity, the Philippines is ranked 5th in the number of plant species and maintains 5% of the world's flora. This states that there is a wide variety and availability of plants in the Philippines. Additionally, there are also many mothers who collect plants in their respective homes. These plants have good benefits in life such as beautifying a place,reducing sound levels and stress, but most importantly, it helps decrease the amount of harmful gasses present in the atmosphere. Multiple indoor plants such as the Sansevieria trifasciata (Snake Plant), Codiaeum variegatum (Garden Croton), and Epipremnum aureum (Golden Pothos) are widely available in the Philippines and they help in increasing the amount of air quality while slowly removing toxins and harmful gasses present, providing a cleaner and fresher atmosphere. With the use of an arduino, monitor and sensor, a device can be further developed to determine the percentage of air quality. This can inform the user on the amount of harmful gasses present in a certain area and it can detect harmful gasses present in the atmosphere by showing the percentage level of air quality. The amount of air quality increases as the percentage level drops,providing a cleaner and less polluted environment for all. By detecting the amount of air quality and using the Sansevieria trifasciata (Snake Plant), Codiaeum variegatum (Garden Croton), and Epipremnum aureum (Golden Pothos) , this study aims to detect and potentially decrease the amount of harmful gasses present in the atmosphere, ensuring the safety and wellness of our surroundings while providing a cleaner and suitable environment for all.

Background and Significance

As of 2023, the Philippines was ranked 79 in having the worst air quality in the world. As stated by the Department of Health in the Philippines, there have been increasing respiratory issues of children amongst polluted areas. This can cause severe risks to living organisms and can potentially cause greater problems in the future. It shows that the environment has a significant effect in the health and lifestyle of a person, causing them to have more problems in the future. There are many ways to improve air quality, most of them require investing on high quality yet costly devices. Inflation has caused citizens in the Philippines to have difficulty in investing on costly products and finding solutions to health problems and homes caused by poor air quality.

This study is significant for the reason that it aims to improve the air quality in the environment by providing potential solutions to further avoid possible health conditions and help in the improvement of air purifying technology to make an innovative, convenient, and safe environment for people to live in. It aims to lessen the amount of pollutants and harmful gasses in the atmosphere that may be causes of health problems that people are unconscious of. Medical issues may decrease and indoor air quality can be improved. With the use of the digital monitor, people will be informed about the amount of gasses present and will know which plant to use indoors for their homes, offices, etc.

In this study, the Snake plant, Garden Croton, and Golden Pothos will be conducted on 3 separate experiments in 3 various conditions. These plants are very accessible and affordable in the Philippines, they are also known for being indoor plants that have air purifying properties and they can last long. An arduino with codes will be attached to a digital monitor device that presents the percentage (ppm) of the amount of harmful gasses present.Each test will be done inside a sealed box environment, ensuring that no treatment will escape the given environment. The first experiment will be held constant to be used as a basis of the present air in the environment with no treatment. After this, 2 treatments will be done in the experiment in which the data will be collected every 2 hours for a span of 12 hours per plant. The first treatment is smoke, cardboard will be lit to produce smoke which is emitted throughout the sealed box. As for the second These experiments are done to determine whether the certain plant has properties of possibly decreasing the percentage of harmful gasses present and whether the device accurately measures the gasses present.

This study aims to accurately detect and present the amount of harmful gasses present in the atmosphere while further eliminating the harmful gasses present in the atmosphere. The device can detect and measure the amount of harmful gasses present, mainly benzene and carbon dioxide.This can provide a cleaner and suitable environment to live in, especially that air pollution is getting worse day by day. This device and the following plants may have possible limitations and weaknesses which may cause potential failure in detecting the gasses present. This research study can also be used as a basis for the improvement of certain devices and can be used for the generations to come. To further improve the device, further research is recommended.

Statement of the Problem

The primary research question addressed in this study is as follows:

Main Problem: How effective are Sansevieria trifasciata (Snake Plant), Codiaeum variegatum (Garden Croton), and Epipremnum aureum (Golden Pothos) in removing harmful gasses?

This main problem is broken down into the following sub-problems

Sub-Problems:

1.) How well does the Air Quality detector distinguish between typical air conditions and those tainted by smoke or paint particles, particularly within specific indoor plant species?

2.)How can the scientific understanding of eliminating harmful gasses be effectively translated into actionable recommendations for improving indoor air quality in homes, workplaces, and public spaces?

3.)How is the air quality detector able to monitor and measure harmful gasses and other compounds that are present within the air?

Hypothesis

Ha:

Sansevieria trifasciata (Snake Plant), Codiaeum variegatum (Garden Croton), and Epipremnum aureum (Golden Pothos) effectively reduce the percentage of harmful gases present in the atmosphere when compared to baseline air conditions.

Ho:

There is no significant difference in the reduction of harmful gases between Sansevieria trifasciata (Snake Plant), Codiaeum variegatum (Garden Croton), and Epipremnum aureum (Golden Pothos) when compared to baseline air conditions.

Scope and Delimitations

Scope:

This study primarily aims to enhance indoor air quality (IAQ) by developing air quality detectors for the assessment of specific indoor plant species' effectiveness: Sansevieria trifasciata (Snake Plant), Codiaeum vareriegatum (Garden Croton), and Epipremnum aureum (Golden Pothos) in removing harmful gasses from indoor environments. The research focuses on these three commonly chosen indoor plant varieties recognized for their air-purifying properties, with the intention of providing quantitative insights into their ability to contribute to improved indoor air quality. The study's core methodology revolves around rigorous quantitative analysis, employing air quality detectors to precisely measure changes in gas concentrations in the presence of the selected plants, ensuring data-driven conclusions regarding their air-purifying efficacy.

Delimitations:

However, several delimitations must be acknowledged. Firstly, the study's scope is constrained to the chosen indoor plant varieties and may not account for the full spectrum of indoor plants utilized for indoor air quality enhancement. The study will not encompass the entire range of harmful gasses and will mainly focus on Volatile Organic compounds and carbon dioxide since it is the most common harmful gas in high concentrations present in the atmosphere, limiting the generalizability of the results. The short-term nature of the study might not capture prolonged trends in the removal of these certain gasses and the controlled laboratory conditions may not fully replicate the complexity of real-world indoor spaces. Finally, the research does not encompass external factors such as outdoor pollutants infiltrating indoor spaces, which can influence air quality but fall beyond the study's defined scope. The air quality detector will only be used in places that have low ventilation such as closed places that are exposed to chemicals.

Literature Review

The air quality detector's usage is to detect harmful gasses. This can help assess the air's quality in terms of the abundance of gasses and particles. Many studies and devices such as Air Quality and VOC detectors and sensors have proven the importance of harmful gas counting and why detectors must be used to ensure that all harmful gasses, especially carbon dioxide are detected.. Although most of these studies only show the importance of gas detectors, this will be used as a guide in improving the system for the study. With these related studies, this study aims to further enhance these findings and provide their applicability in detection of harmful gasses in numerous applications requiring portable and easy-to-use devices (such as frequent safety and environmental monitoring, food and beverage quality assessment, and medical monitoring and diagnostic devices). However, as a result of using a large number of sensors, these devices are expensive in terms of both the costs of the sensors and maintenance and calibration that is required due to the drifts of the components of the sensor array. This study shows that air quality detectors may be expensive despite the accuracy in detecting VOCs. The size of the detector can also limit the applicability of these systems in real life, as it requires this device to be handy for people to use easily. With this study, the automatic air quality detector ensures that it will be convenient for everyone to use at a cheaper price while having accurate results of the amount of harmful gasses present in the atmosphere.

Shamasunder et al. (2018) stated that next-generation monitoring technologies, such as low-cost air quality sensors, used in combination with conventional techniques are an approach that may be able to help address these needs. Low-cost sensing systems often cost orders of magnitude less than conventional instruments on a per-unit basis and are simpler to deploy and operate, making them particularly well-suited to provide preliminary or supplementary data for community-based projects or projects in partnership with environmental justice communities where resources may be limited. This proves that it is important to have low-cost sensors in order for these devices to be used anywhere, with specific limitations. MOx sensors are composed of a metal-oxide surface (often tin dioxide), a sensing chip to measure changes in conductivity, and a heater. These sensors were developed for and are typically used in scenarios in which high pollutant concentrations would be expected, such as in an industrial setting or inside a vehicle engine. These types of sensors could also supplement conventional monitoring methods. The MQ-135 gas sensor is used to measure the concentration of various gases in the air, such as Ammonia, Nitrogen Oxide, Alcohols, Aromatic Compounds, Sulfide, and Smoke. It operates by detecting changes in resistance when exposed to different gases. To measure the concentration in parts per million (PPM), the sensor needs to be calibrated by finding the values of sensor resistance in fresh air (Ro) and in the presence of gas (Rs). The ratio of Rs/Ro is then used to calculate the equivalent PPM value based on a sensitivity graph provided in the sensor's datasheet.

According to Beare.com, the golden pothos plant is one of the best household plants for purifying the air and removing toxins. Their roots, stems and leaves contain calcium oxalate crystals that are toxic to humans and animals but it can remove toxins and volatile organic compounds.Another study done by NASA indicates that it can remove common VOC's present in spacecrafts and household indoor air and decreasing the necessity for active cabin trace contaminant removal systems.

The Sansevieria trifasciata (Snake Plant) is commonly used as an air purifier for indoor environment. According to a study conducted by NASA, it has consistently shown the plant to remove toxins such as formaldehyde, xylene, toluene, and nitrogen oxides—which means that industries and workspaces such as automotive plants and shops, aircraft plants, plywood, carpeting, paint makers and sellers, printing, and offices, where these chemicals abound in the products produced and used, would greatly benefit by keeping several Sansevieria around. It is also hard to kill and easy to maintain in a household. Lastly, the garden croton is one of the generous houseplants that purify the surrounding air. It can be use to control pests and it can absorb formaldehyde, a common volatile organic compound. Its wide leaves can absorb the volatile organic compounds, lessening the toxins in the air.

The cited studies emphasize the importance of air quality detectors for health, environmental, and safety reasons. They highlight the limitations of existing systems like mass spectrometry and gas chromatography, mainly related to cost and portability. In response to these limitations, the study aims to develop an automatic air quality detector that combines accuracy with affordability and convenience, addressing the need for widespread adoption. Additionally, the research discusses the sources and health implications of the effects of harmful gasses, stressing the necessity of monitoring and removing them. Furthermore, it explores the potential of low-cost air quality sensors to supplement conventional techniques. Ultimately, your study contributes to creating cost-effective, efficient, and user-friendly air quality detection and removal , providing benefits for both the environment and public health.

METHODOLOGY

Research Design

The research design for this study is experimental. This approach enables a systematic investigation of the effectiveness of the selected plants in removing VOCs from indoor air. Specifically, it focuses on the development and application of VOC detectors in controlled settings.

Sampling Techniques

Purposive sampling is integral to our research procedure, which investigates the impact of specific indoor plant species on the reduction of Volatile Organic Compounds (VOCs) in a controlled environment. Throughout the research, purposive sampling is applied in the deliberate selection of key elements such as the chosen plant species known for their air-purifying qualities, the specific materials used for controlled environments, the sensors compatible with VOC detection, and the time intervals for VOC measurements. This approach ensures that our research is closely aligned with our defined objectives, enabling us to focus on the specific aspects and variables that are essential to understanding the effect of indoor plants on VOC reduction.

Materials

- Arduino Uno
- Plywood
- Sansevieria trifasciata (Snake Plant)
- Codiaeum variegatum (Garden Croton)
- Epipremnum aureum (Golden Pothos)
- Male and Female Jumper Wires
- Plexiglass
- Rugby
- Nails
- Pot (medium-size)

- Hammer

- LCD 16x2 Display

- Laptop

- MQ 135 air quality gas sensor module

- I2C Serial Interface Board

- Arduino AC/DC Adaptor

- Soldering iron

- Soldering lead

- Duct tape

- Screw

- Phillips screwdriver

-Cardboard

- Lighter

- Paint

Figure 1: Conceptual Framework

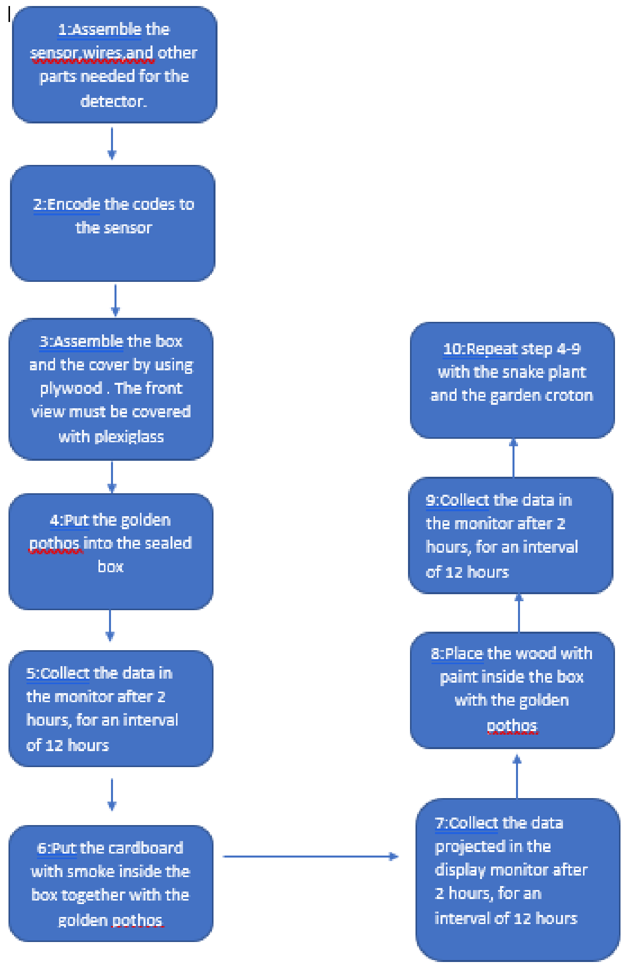

Figure 2: Front view of the Model of the detector

Procedures

I. Materials and Assembling the Detector:

I.1 Gathering Materials:

For a successful construction of our VOC (Volatile Organic Compounds) detector, we need to gather an array of materials. These materials include:

- Arduino Uno: The central component that controls and processes data.
- Male to Female Jumper Wires: Necessary for connecting and securing various components.
- Soldering Iron w/o Analog Soldering Station: Used to heat the soldering lead
- Soldering Lead: By applying heat, its liquid-like state can be used to attach certain parts of a device.
- MQ 135 Sensor: The primary component responsible for VOC detection.
- LCD 16x2 Display: Provides real-time information on VOC levels.
- I2C Serial Interface Board: Used in Arduino to allow communication between a master (Arduino) and one or more slave devices, enabling data exchange and configuration, in this case the I2C LCD 16x2 Display
- USB 2.0 Cable Type A/B - Used to upload the created sketch from the Computer to the Arduino board.
- AC/DC Power Supply (6 volts) - Providing a stable and required amount of volts for the Arduino board to run.
- Plywood: Material in making the outer dimensions of the box

- Sketches for Arduino: To be encoded, but crucial for the functioning of our detector.
- Laptop: To input the sketch
- Arduino IDE: Software used to activate, declare, and upload the sketch.

I.2 Attach the LCD 16x2 display with the I2C Serial Interface Board

The LCD display will be used to show the number of particles present per queue. However, an external device is needed to establish a connection from the central board to the external devices. To do so, I2C Serial Interface Board is needed to establish such a connection with the display. I2C Serial Interface Board converts I2C serial data to parallel data for the LCD display.

1. Preparation
   - Gather all necessary equipment: soldering iron, soldering lead, I2C Serial InterfaceBoard, LCD display, Male to Female jumper wires.
   - Ensure a clean and well-lit workspace with adequate ventilation.
2. Attach the Serial Interface Board to the display
   - Heat the soldering iron and when it starts to smoke, turn the appliance off. Then insert the 16 pins of the Serial Interface Board to the 16 ports of the LCD display.
   - Gently place a strip of soldering lead to each pin and using the soldering iron, melt the strip to cover every port to ensure a sealed and tight connection between the two devices.
   - Let it sit in order for the soldering lead to harden.

I.3 Connect the Display to the Arduino Uno

1. Prepare the Jumper wires

- Prepare 4 Male to Female Jumper Wires

2. Jumper Wire Connection

    - The Female head of the wire shall be inserted to the I2C's ports and the Male head of the wire shall be plugged to the ports located on the Arduino Board:

*SDA wire to SDA pin

*SCL wire to SCL pin

*VCC wire to VCC pin

*GND wire to GND pin

3. Turn on the Arduino Board

    - For now, connect the Arduino board to the Laptop using the USB 2.0 Cable Type A/B to activate the board.
    - The display shows a bit of lighting, therefore it is now activated.

4. Initialize the Arduino Board

    - Open the Arduino IDE software and go to the port settings and find the serial port of the laptop connected and the type of Arduino being used, in this case the Arduino Uno Series.

5. Test the display

    - Go to Sketch > Examples > Display, and open a sketch to upload a code for it to execute. The device showed some demo text therefore the display has a connection to Arduino.

I.4 Attach the MQ 135 sensor to the Arduino Board

The assembly of our detector is a crucial process, ensuring that our air quality detection system is both functional and user-friendly. The steps involved in assembling the detector are as follows:

1. Hardware setup:
    - Connect the MQ-135 sensor to the Arduino board. The sensor's analog pin should be connected to the Arduino's analog input pin A0.
    - Connect the LCD display to the I2C pins on the Arduino board. The SDA pin should be connected to the SDA pin on the Arduino, and the SCL pin should be connected to the SCL pin on the Arduino.
2. Include required libraries:
    - Include the Wire.h library for I2C communication.
    - Include the MQ135.h library for working with the MQ-135 sensor.
    - Include the LiquidCrystal_I2C.h library for controlling the LCD display.
3. Initialize variables and objects:
    - Define the analog pin used for the MQ-135 sensor.
    - Create an LiquidCrystal_I2C object with the I2C address and dimensions of the LCD display.
    - Create an MQ135 object with the analog pin used for the sensor.
4. Setup function:
    - Start the serial communication with a baud rate of 9600.
    - Initialize the LCD display with the begin() function, specifying the dimensions of the display.
    - Print a message to the LCD display indicating that the system is initializing.
    - Wait for 2 seconds using the delay() function.

- Clear the LCD display using the clear() function.

5. Loop function:

- Read the sensor value using the getRZero() function of the MQ135 object. This function returns the resistance of the sensor in a clean air environment.
- Calculate the VOC value using the getPPM() function of the MQ135 object. This function takes the resistance value and calculates the VOC concentration in ppm.
- Print the VOC value to the serial monitor using the print() and println() functions.
- Set the cursor position on the LCD display to print the VOC value.
- Print the message "Air Quality:" followed by the VOC value in ppm on the LCD display using the print() function.
- Wait for 10 seconds using the delay() function.
- Clear the LCD display using the clear() function.

6. Compile and upload the sketch to the Arduino board.

7. Observe the VOC concentration in ppm on the serial monitor and the LCD display.

- Assemble the wires and attach the sensor carefully to establish the vital connections required for accurate gas detection.

- Place the digital display counter on top of the Arduino setup, providing a visual representation of air quality levels.

II. Creating the Box Setup:

For the box setup, we will require the following materials - plywood and plexiglass. The assembly process begins by cutting these materials into pieces measuring 2ft by 3ft for the five sides of the box. These pieces are then securely attached using nails and a hammer, forming a sturdy enclosure. The researchers also applied duct tape on the crevices of the box in order to not allow air to escape outside into the environment. For the 5th plywood, we will be making a cover so that the box can be opened and closed. On the front of the box, we will measure the remaining space for the plexiglass. The plexiglass must be cut before attaching it to the box.

III. Attaching the Detector to the Box:

With the box now prepared, the next step involves attaching the detector to the box setup. The detector is crucial for measuring the amount of harmful gasses such as carbon dioxide and VOCs present within our experimental environment. Using a drill, we drilled several holes into the right side of the box and aligned each hole with the designated holes that are present in the Arduino board. Then, using a phillips screwdriver and some phillips head screws, we safely attached the device without scratching its rods.

IV. First Experiment: Golden Pothos with smoke

Every experiment will take 12 hours to complete. The golden pothos will be placed inside the box and the detector must be turned on for the first 5 minutes. After 5 minutes, the initial parts per million (ppm) should be measured. This indicates the initial air quality without the smoke and the effects of the golden pothos to remove these harmful gasses. A cardboard must be cut 6x2to emit more smoke in the box. A lighter must be used to burn the sides of the cardboard. Once the fire slowly disintegrates, it should emit a large amount of smoke. This cardboard must be placed inside the box, on top of a metal cap. The box should be closed and duct tape must be used on the sides of the box to ensure that no air will spread outside of the experimental environment. The detector should be turned off for a span of 2 hours. After 2 hours, the detector should be plugged and it should measure the amount of harmful gasses present in the air for 5 minutes. Once it is done, the amount of ppm should be recorded. This process should be repeated 6 times a day, under 12 hours.

V. Second Experiment: Golden Pothos and paint

A plywood sheet measuring 6x6 must be cut and painted. The golden pothos must be put inside the box and the detector should measure the amount of harmful gasses for 5 minutes. Once it is done, the plywood must be placed inside the box and on top of a plastic. The paint must be dried and put inside the box for 2 hours. After 2 hours, the detector should be plugged and it should measure the amount of harmful gasses present in the air for 5 minutes.Once it is done, the amount of ppm should be recorded. This process should be repeated 6 times a day, under 12 hours.

VI. Third experiment: Snake plant with smoke

The same procedure in experiment 1 should be followed. The snake plant will be put in the box and for the first 5 minutes, the detector should be plugged and should measure the amount of gasses in the air. After this, the cardboard with smoke must be placed inside the box for 2 hours. After 2 hours, the detector must be plugged and it should measure the amount of harmful gasses present for 5 minutes. This process should repeat 6 times under 12 hours.

VII. Fourth experiment: Snake plant and paint

The same procedure from the second experiment will be used. A plywood sheet measuring _ must be cut and painted. The snake plant must be put inside the box and the detector should measure the amount of harmful gasses for 5 minutes. Once it is done, the plywood must be placed inside the box and on top of a plastic. The paint must be dried and put inside the box for 2 hours. After 2 hours, the detector should be plugged and it should measure the amount of harmful gasses present in the air for 5 minutes.Once it is done, the amount of ppm should be recorded. This process should be repeated 6 times a day, under 12 hours.

VIII.Fifth experiment: Garden Croton with smoke

The garden croton will be placed inside the box and the detector must be turned on for the first 5 minutes. After 5 minutes, the initial parts per million (ppm) should be measured. This indicates the initial air quality without the smoke and the effects of the golden pothos to remove these harmful gasses. A cardboard must be cut 6x2 to emit more smoke in the box. A lighter must be used to burn the sides of the cardboard. Once the fire slowly disintegrates, it should emit a large amount of smoke. This cardboard must be placed inside the box, on top of a metal cap. The box should be closed and duct tape must be used on the sides of the box to ensure that no air will spread outside of the experimental environment. The detector should be turned off for a span of 2 hours. After 2 hours, the detector should be plugged and it should measure the amount of harmful gasses present in the air for 5 minutes. Once it is done, the amount of ppm should be recorded. This process should be repeated 6 times a day, under 12 hours.

IV. Sixth experiment: Garden Croton and paint

For our last experiment, the same procedure for the second experiment will be used. A plywood sheet measuring _ must be cut and painted. The garden croton must be put inside the box and the detector should measure the amount of harmful gasses for 5 minutes. Once it is done, the plywood must be placed inside the box and on top of a plastic. The paint must be dried and put inside the box for 2 hours. After 2 hours, the detector should be plugged and it should measure the amount of harmful gasses present in the air for 5 minutes.Once it is done, the amount of ppm should be recorded. This process should be repeated 6 times a day, under 12 hours.

X.Seventh experiment:Garden Croton without treatment

This is done to be the controlled group in this experiment. There are no treatments involved except for the air present inside the sealed box. The garden croton will be placed inside the sealed box and data will be collected every 2 hours for a span of 12 hours.

XI.Eight experiment:Snake plant without treatment

As stated in the seventh experiment, it is controlled and there are no treatments involved in this experiment. The snake plant will be placed inside the sealed box and data will be collected every 2 hours for a span of 12 hours.

XII.Ninth experiment:Golden Pothos without treatment

Lastly, this experiment has the same condition as the seventh and eighth experiment. There is no treatment but the golden pothos will be sealed inside the box. The air quality will be measured every 2 hours for a span of 12 days.

These experiments serve as a comparison for the 3 different plants in terms of their ability to lessen the amount of harmful gasses present in the atmosphere. It also shows the different concentrations that smoke and paint can emit to the atmosphere which have potential negative effects not only to the human body but also to the world around us.

Results

The following 3 tables below show the data collected in the experiment discussed in the procedures above, using the Golden Pothos plant. Table 1 is the first experiment, it contains the data obtained by the researchers using the air quality detector to measure the amount of harmful gasses present in a box filled with smoke in ppm. Table 2 is the second experiment, it shows the data collected by the researchers where the detector measures the amount of harmful gasses present in the box with paint being applied. Table 3 is the third experiment and the control variable, only containing normal air extracted from the outside environment. This is done in order to compare with the results in the two independent variables.

Table 1- Golden Pothos with smoke

Amount of time	**Amount of harmful gasses present**
2 hours	76.28 ppm
4 hours	75.83 ppm
6 hours	75.37 ppm
8 hours	75.37 ppm
10 hours	74.92 ppm
12 hours	74.72 ppm

Table 2- Golden pothos with paint

Amount of time	**Amount of harmful gasses present**
2 hours	74.92 ppm
4 hours	75.57 ppm
6 hours	65.06 ppm
8 hours	65.47 ppm

10 hours	67.12 ppm
12 hours	67.86 ppm

Table 3- Golden pothos with normal air

Amount of time	Amount of harmful gasses present
2 hours	55.80 ppm
4 hours	56.16 ppm
6 hours	52.53 ppm
8 hours	50.84 ppm
10 hours	48.50 ppm
12 hours	44.31 ppm

The following 3 tables below show the measurements in ppm of the experiment explained above in the procedure by the researcher, with Snake plant being used. Table 4 is the fourth experiment, it shows the data collected by the detector after smoke is applied inside the box. Table 5 is the fifth experiment, it contains the data obtained by the researchers from the detector after applying paint. Table 6 is the sixth experiment and a control variable for the Snake plant, it is done in order to compare with the 2 independent present in the experiments.

Table 4- Snake plant with smoke

Amount of time	Amount of harmful gasses present
2 hours	63.85 ppm
4 hours	64.66 ppm
6 hours	62.65 ppm
8 hours	63.05 ppm

10 hours	63.85 ppm
12 hours	63.05 ppm

Table 5- Snake plant with paint

Amount of time	**Amount of harmful gasses present**
2 hours	60.69 ppm
4 hours	61.47 ppm
6 hours	65.47 ppm
8 hours	65.88 ppm
10 hours	65.38 ppm
12 hours	65.88 ppm

Table 6- Snake plant with normal air

Amount of time	**Amount of harmful gasses present**
2 hours	60.30 ppm
4 hours	61.47 ppm
6 hours	61.86 ppm
8 hours	61.06 ppm
10 hours	61.08 ppm
12 hours	60.69 ppm

The 3 following tables below show the data obtained by the researchers from the detector in ppm after applying smoke, paint, and normal air into the Garden Croton plant. Table 7 is the seventh experiment, it contains data obtained by the detector when the Garden Croton plant was treated with smoke. Table 8 is the eighth experiment, it shows the data obtained by the detector after the plant was treated with paint. Table 9 is the ninth experiment and the last, this is the control variable and it is done in order to compare with the 2 independent variables of Garden Croton.

Table 7- Garden Croton with smoke

Amount of time	**Amount of harmful gasses present**
2 hours	60.30
4 hours	59.15
6 hours	59.54
8 hours	60.30
10 hours	60.69
12 hours	60.38

Table 8-Garden Croton with paint

Amount of time	**Amount of harmful gasses present**
2 hours	54.71
4 hours	62.26
6 hours	61.68
8 hours	61.86
10 hours	61.47
12 hours	60.69

Table 9-Garden Croton with normal air

Amount of time	**Amount of harmful gasses present**

2 hours	61.86
4 hours	61.86
6 hours	62.26
8 hours	62.65
10 hours	62.26
12 hours	61.86

Data Analysis

In this section, we outline the proposed data analysis plan for our research, which aims to investigate the impact of indoor plants on the reduction of harmful gasses in an enclosed environment. As discussed in the introduction, this research seeks to address the critical question of whether the presence of specific indoor plants can effectively reduce harmful gas concentrations, thereby improving indoor air quality. We hypothesize that the selected plant species, including Sansevieria trifasciata (Snake Plant), Codiaeum variegatum (Garden Croton), and Epipremnum aureum (Golden Pothos), will contribute to a significant decrease in the harmful gas levels. Our research proposal outlines the methods that will be employed in constructing the air quality detector and setting up controlled environments using both plywood and plexiglass boxes. We will collect data from two separate experiments, each lasting three days. For data analysis, we plan to employ statistical tools such as Analysis of Variance (ANOVA) to assess differences in gas concentrations among the different experiments and time points. Additionally, we will utilize paired t-tests to compare these measurements before and after the introduction of indoor plants, and code modifications in the third experiment. These statistical methods will allow us to determine the statistical significance of our findings. Based on our research design and the hypothesis that indoor plants will lead to a reduction in harmful gas levels, we anticipate that the data will show a consistent decrease in these concentrations in the presence of these selected plant species. The statistical tools mentioned above will help confirm the significance of these changes.

A total of 54 samples were taken from the experiment.The experiment took place in Mangnao, Dumaguete City in which the samples were taken every 2 hours for 9 days. Thus, the data for each plant is collected on a separate day according to each of the 3 different conditions: the plant staying constant, exposed to smoke and exposed to paint. The data was divided into 3 groups per plant:Golden Pothos, Snake Plant and the Garden Croton. The following 9 tables below are the results calculated by the researchers in order to see the percentage increase or decrease of the harmful gasses present inside the box after the 3 different plants were left inside. This will allow the researchers to conclude if the plants are effective at absorbing harmful gasses present in the atmosphere or a given area.

Table 10: Change in percentage of smoke in Golden Pothos

Percentage Change	
Initial - 76.28 ppm Final - 74.72 ppm	2.05% Decrease

Table 11: Change in percentage of paint in Golden Pothos

Percentage Change	
Initial - 74.92 ppm Final - 67.86 ppm	9.42% Decrease

Table 12: Change in percentage of harmful gasses in normal air in Golden Pothos

Percentage Change	
Initial - 55.80 Final - 44.31	20.60% Decrease

Table 13: Change in percentage of smoke in Snake plant

Percentage Change	
Initial - 63.85 Final - 63.05	1.25% Decrease

Table 14: Change in percentage of paint in Snake plant

Percentage Change	
Initial - 60.69 Final - 65.88	8.60% Increase

Table 15: Change in percentage of harmful gasses in normal air in Snake plant

Percentage Change	
Initial - 60.30 Final - 60.69	0.65% Increase

Table 16: Change in percentage of smoke in Garden Croton

Percentage Change	
Initial - 60.30 Final - 60.38	0.13% Increase

Table 17: Change in percentage of paint in Garden Croton

Percentage Change	
Initial - 54.71 Final - 60.69	10.93% Increase

Table 18: Change in percentage of harmful gasses in normal air in Garden Croton

Percentage Change	
Initial - 61.86 Final - 61.86	0%

The 6 tables below are the results of the t-test conducted by the researchers in order to determine if the detector can see the difference between normal air and air filled with harmful gasses, given a certain area determined by the researchers.

Table 19: T-test on the before and after applying smoke on Golden Pothos

Before smoke	After smoke	T Table Value	Critical t-value	Interpretation
55.80	76.84	2.015	-6.03	Significant Difference
56.16	78.63			
52.23	76.28			
50.84	75.83			
48.50	75.37			
44.31	74.92			

Table 20: T-test on the before and after applying paint on Golden Pothos

Before paint	After paint	T Table Value	Critical t-value	Interpretation
55.80	74.47	2.015	-11.32	Significant Difference
56.16	74.92			
52.23	75.57			
50.84	65.06			
48.50	65.47			
44.31	67.12			

Table 21: T-test on the before and after applying smoke on Snake Plant

Before smoke	After smoke	T Table Value	Critical t-value	Interpretation
60.30	63.85	2.015	-6.10	Significant Difference
61.47	64.66			
61.86	62.65			
61.06	63.05			
61.08	63.85			
60.69	63.05			

Table 22: T-test on the before and after applying paint on Snake Plant

Before paint	After paint	T Table Value	Critical t-value	Interpretation
60.30	60.69	2.015	-3.13	Significant Difference
61.47	61.47			
61.86	65.47			
61.06	65.88			
61.08	65.38			
60.69	65.88			

Table 23: T-test on the before and after applying smoke on Garden Croton

Before smoke	After smoke	T Table Value	Critical t-value	Interpretation
61.86	60.30	2.015	-8.59	Significant Difference
61.86	59.15			
62.26	59.54			
62.65	60.30			
62.26	60.69			
61.86	60.38			

Table 24: T-test on the before and after applying paint on Garden Croton

Before paint	After paint	T Table Value	Critical t-value	Interpretation
61.86	60.30	2.015	0.54	Significant Difference
61.86	59.15			
62.26	59.54			
62.65	60.30			
62.26	60.69			
61.86	60.38			

Risk Assessment

First, in terms of health and safety, we recognize a minor risk related to the choice of indoor plants, primarily due to potential toxicity if ingested. To mitigate this, proper labeling and educational measures will be implemented to ensure safe handling. Additionally, while the goal is to reduce harmful gas levels, there is a minimal risk of exposure to these gasses during the experiments, necessitating precautions and protective equipment. Electrical risks are also present during the assembly of the Arduino setup, demanding careful handling of components to avoid shocks or short circuits. To address this, experienced personnel will supervise this stage. Proper plant care is crucial to mitigate potential environmental risks, as neglecting the well-being of the selected plant species could influence research outcomes. Lastly, when modifying the code for the Arduino setup, the risk of programming errors exists, potentially impacting data accuracy. Mitigation efforts include code backups and rigorous testing to minimize this risk throughout the project.

Discussion

The researchers will first discuss tables 1 until table 18, in this portion the researchers will discuss the change in percentage between the initial and final value of the data collected by the detector during the experiment.

As shown in Table 10, it indicates the change in percentage of smoke present in the box. After calculating, we get a result of 2.05% decrease in the final total amount of smoke present in the box compared to the initial total amount. With this, the researchers can conclude that the Golden Pothos plant is effective at removing 2.05% of smoke given an area.As for Table 11, it shows the change in percentage of paint present in the box. After calculating, the researchers got a result of a 9.42% decrease in the final total amount of paint present in the box compared to the initial total amount. The researchers can conclude that the Golden Pothos plant is capable of removing 9.42% of harmful paint particles given an area.

Table 12 shows the change of percentage of harmful gasses present in normal air collected from the local environment. After carefully calculating, the researchers got the result of a 20.60% decrease of harmful gasses present in the normal air applied in the box. With that, the researchers can conclude that the Golden Pothos plant is able to absorb 20.60% of harmful gasses present in the normal air present in the atmosphere given an area.The difference between the initial and final proportion of smoke in the box is displayed in table 13. After computation, the researchers found that there was a 1.25% reduction in the total amount of smoke in the box at the end as opposed to the beginning. This leads the researchers to the conclusion that, in a given area, the Snake plant effectively removes 1.25% of smoke.

The percentage difference between the initial and final harmful paint particles inside the box is displayed in table 14. After making calculations, the researchers discovered that there were 8.60% more harmful paint particles in the box overall than there had been at the beginning. The researchers deduce that the Snake plant is incapable of eliminating harmful paint particles from a particular area. With an increase of the overall amount of toxic gas by 8.60%.

Table 15 displays the change in percentage of dangerous gasses found in typical air that was gathered from the nearby surroundings. The outcome of the calculations done by the researchers showed that the amount of hazardous gasses in the regular air applied to the box had increased by 0.65%. Based on this, the researchers can conclude that the Snake plant is ineffective at absorbing toxic gasses found in the typical air in a given area. For Table 16, it shows the percentage change between the initial and final amounts of smoke in the box. The overall amount of smoke in the box increased by 0.13%% at the end of the experiment compared to the beginning, the researchers calculated. This leads the researchers to conclude that the Garden Croton is not successful at eliminating smoke in a specific region.

Table 17 shows the percentage difference between the initial and final hazardous paint particles inside the box. The researchers calculated the total amount of paint in the box and found that it was 10.93% greater than it had been initially. The researchers conclude that dangerous paint particles cannot be removed from a specific region by the Snake plant. With a 10.93% increase in the total amount of hazardous gas.

The percentage of hazardous gasses that changed in average air collected from the surrounding area is shown in table 18. The researchers' calculations yielded a result indicating that there had been no change in the quantity of harmful gasses present in the ordinary air applied to the box (i.e., 0%). This leads the researchers to the conclusion that the Snake plant is not capable of absorbing harmful gasses present in the normal air in a particular area.

The researchers will now discuss the results of the calculations of multiple t-tests done by the researchers in order to conclude if the detector can detect the differences between the harmful gasses to normal air particles. The null hypothesis is that there is no significant difference between the groups being compared, the alternative hypothesis is that there is a significant difference between the groups being compared. It is important to keep in mind that if the critical t-value is less than the t table value, then the researchers will reject the null hypothesis.

Table 19 shows the calculated critical t-value between normal air and smoked applied air with the plant Golden Pothos, with the calculated critical t-value being equal to -6.03 and the t table value being equal to 2.015. The critical t-value is less than the t-table value, so the researchers can reject the null hypothesis. With that, the researchers can also conclude that the detector can detect the difference between normal air and smoked filled air. The computed critical t-value between normal air and paint particle applied air with the plant Golden Pothos is displayed in table 20. The t-table value is 2.015, while the computed critical t-value is equal to -11.32. The researchers can reject the null hypothesis because the critical t-value is smaller than the t-table value. This leads the researchers to the further conclusion that the detector is capable of differentiating between air that is free of paint particles and air that is not.

Table 21 shows the calculated critical t-value between smoke-applied air and normal air with the Snake plant. The calculated critical t-value is equivalent to -6.10, whereas the t-table value is 2.015. Because the critical t-value is less than the t-table value, the researchers can reject the null hypothesis. This further leads the researchers to the conclusion that the detector can distinguish between smoke-free and non-smoke-free air. As for Table 22, it shows the calculated critical t-value between normal air and paint particle applied air with the Snake plant. The computed critical t-value is equal to -3.13, and the t-table value is 2.015. Because the critical t-value is less than the t-table value, the researchers can reject the null hypothesis. This further leads the researchers to the conclusion that the detector can distinguish between paint-particle-free and paint-particle-filled air.

The computed critical t-value for smoke-applied air and regular air with the Garden Croton is displayed in table 23. The t-table value is 2.015, while the computed critical t-value is equal to -8.59. The researchers are able to reject the null hypothesis since the critical t-value is smaller than the t-table value. This further supports the researchers' hypothesis that the detector can discriminate between air that is smoke-free and air that is not. For the last table,the computed critical t-value for smoke-applied air and regular air with the Garden Croton is displayed in table 24. While the t-table value is 2.015, the computed critical t-value is equal to 0.54. The researchers are able to reject the null hypothesis since the critical t-value is smaller than the t-table value. This further supports the researchers' hypothesis that the detector can discriminate between air that is smoke-free and air that is not.

Conclusion

Air pollutants may not only contribute to climate change but it also causes severe health risks to humans. Air quality plays a big factor in maintaining one's physical health, maintaining a state of calmness, and most importantly, providing a cleaner, fresher environment for everyone. Thus, it is important to consider the external factors affecting this such as harmful gasses in the atmosphere. However, the air quality detector aids in sensing and detecting these gasses,informing the percentage of gasses present in the atmosphere. It does not only detect these gasses, but it can also distinguish between air that is smoke-free,paint-particle free and air that is polluted with these gasses. Nonetheless, the air quality detector assists in determining the proportion of these dangerous gasses, assisting in the monitoring of indoor air quality. Based on the results, the efficacy of the garden croton, snake plant, and golden pothos vary .The ability of the golden pothos in removing and absorbing these harmful gasses is effective. As for the snake plant, it is effective in absorbing smoke although in terms of removing paint particles and gasses present in normal air, it increases the amount of these harmful gasses. Lastly, the garden croton cannot eliminate nor absorb the smoke and paint-particles, making it ineffective. Despite the fact that the snake plant and the garden croton cannot entirely remove these gasses, the golden pothos can be significant and helpful in maintaining a cleaner atmosphere, which benefits both the local community and the entire planet. It can reduce the chances of getting airborne diseases such as emphysema, asthma, and the like. This ensures that the air quality detector and the Epipremnum aureum (Golden Pothos) can foster in creating a safe, uncontaminated place where people can continue living their everyday lives, without worrying about such matters.

Recommendations

The current study shows that the golden pothos plant was effective in reducing the amount of harmful gasses present in the atmosphere. This proves that the air quality sensor was effective in determining the difference between air that is smoke free, paint particle free and contaminated air. However, the researchers have concluded that there is a lack of information that could possibly improve the said research.

Future research could perform the experiment differently using a different procedure in which a certain pollutant, for example smoke, should be out inside the box for the device to measure the amount of harmful gasses before the plant is placed inside. This assures that it would be more effective in terms of comparison of the percentage for the efficacy of the plant in eliminating these gasses. As for the display monitor, it could also be improved by not only showing the percentage of harmful gasses present based on its increasing value, but also the type of harmful gasses present in the area. Lastly, due to the lack of materials needed to construct the outer covering of the device, which could aid in the improvement of the device, such that it provides structure and frame.

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